

Theory of Backflow and Backsiphonage

A cross-connection¹ is the link or channel connecting a source of pollution with a potable water supply. The polluting substance, in most cases a liquid, tends to enter the potable supply if the net force acting upon the liquid acts in the direction of the potable supply. Two factors are therefore essential for backflow. First, there must be a link between the two systems. Second, the resultant force must be toward the potable supply.

An understanding of the principles of backflow and backsiphonage requires an understanding of the terms frequently used in their discussion. *Force*, unless completely resisted, will produce motion. Weight is a type of force resulting from the earth's gravitational attraction. Pressure (P) is a force-per-unit area, such as pounds per square inch (psi). *Atmospheric pressure* is the pressure exerted by the weight of the atmosphere above the earth.

Pressure may be referred to using an absolute scale, pounds per square inch absolute (psia), or gage scale, pounds per square inch gage (psig). Absolute pressure and gage pressure are related. Absolute pressure is equal to the gage pressure plus the atmospheric pressure. At sea level the atmospheric pressure is 14.7 psia. Thus,

$$P_{\text{absolute}} = P_{\text{gage}} + 14.7 \text{ psi}$$

or

$$P_{\text{gage}} = P_{\text{absolute}} - 14.7 \text{ psi}$$

In essence then, absolute pressure is the total pressure. Gage pressure is simply the pressure read on a gage. If there is no pressure on the gage other than atmospheric, the gage would read zero. Then the absolute pressure would be equal to 14.7 psi which is the atmospheric pressure.

The term *vacuum* indicates that the absolute pressure is less than the atmospheric pressure and that the gage pressure is negative. A complete or total vacuum would mean a pressure of 0 psia or -14.7 psig. Since it is impossible to produce a total vacuum, the term vacuum, as used in the text, will mean all degrees of partial vacuum. In a partial vacuum, the pressure would range from slightly less than 14.7 psia (0 psig) to slightly greater than 0 psia (-14.7 psig).

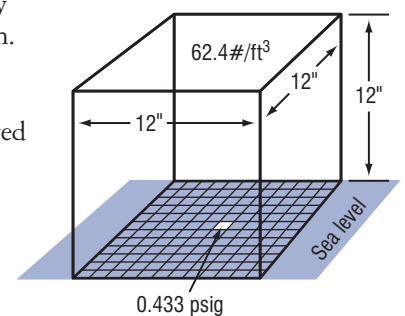
*Backsiphonage*¹ results in fluid flow in an undesirable or reverse direction. It is caused by atmospheric pressure exerted on a pollutant liquid forcing it toward a potable water supply system that is under a vacuum. Backflow, although literally meaning any type of reversed flow, refers to the flow produced by the differential pressure existing between two systems both of which are at pressures greater than atmospheric.

Water Pressure

For an understanding of the nature of pressure and its relationship to water depth, consider the pressure exerted on the base of a cubic foot of water at sea level. (See Fig. 1) The average weight of a cubic foot of water is 62.4 pounds per square foot gage. The base may be subdivided into 144-square inches with each subdivision being subjected to a pressure of 0.433 psig.

Suppose another cubic foot of water were placed directly on top of the first (See Fig. 2). The pressure on the top surface of the first cube which was originally atmospheric, or 0 psig, would now be 0.433 psig as a result of the super-imposed cubic foot of water. The pressure of the base of the first cube would also be increased by the same amount of 0.866 psig, or two times the original pressure.

FIGURE 1. Pressure exerted by 1 foot of water at sea level.

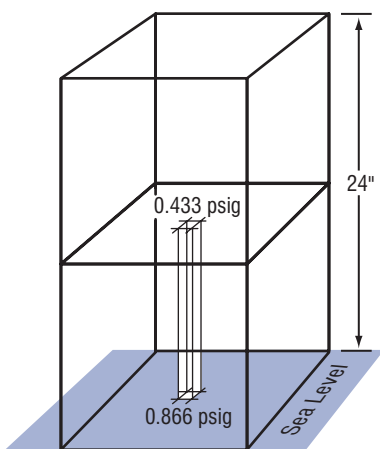


¹See formal definition in the glossary of the appendix

If this process were repeated with a third cubic foot of water, the pressures at the base of each cube would be 1,299 psig, 0.866 psig, and 0.433 psig, respectively. It is evident that pressure varies with depth below a free water surface; in general each foot of elevation change, within a liquid, changes the pressure by an amount equal to the weight-per-unit area of 1 foot of the liquid. The rate of increase for water is 0.433 psi per foot of depth.

Frequently water pressure is referred to using the terms “pressure head” or just “head,” and is expressed in units of feet of water. One foot of head would be equivalent to the pressure produced at the base of a column of water 1 foot in depth. One foot of head or 1 foot of water is equal to 0.433 psig. One hundred feet of head is equal to 43.3 psig.

FIGURE 2. Pressure exerted by 2 feet of water at sea level.

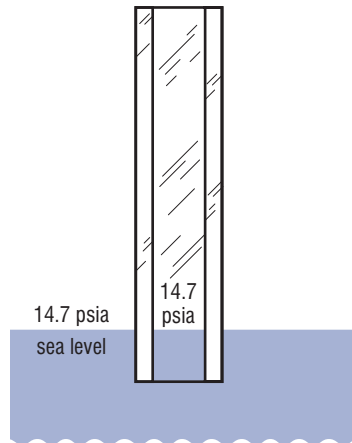


¹See formal definition in the glossary of the appendix

Siphon Theory

Figure 3 depicts the atmospheric pressure on a water surface at sea level. An open tube is inserted vertically into the water; atmospheric pressure, which is 14.7 psia, acts equally on the surface of the water within the tube and on the outside of the tube.

FIGURE 3. Pressure on the free surface of a liquid at sea level.

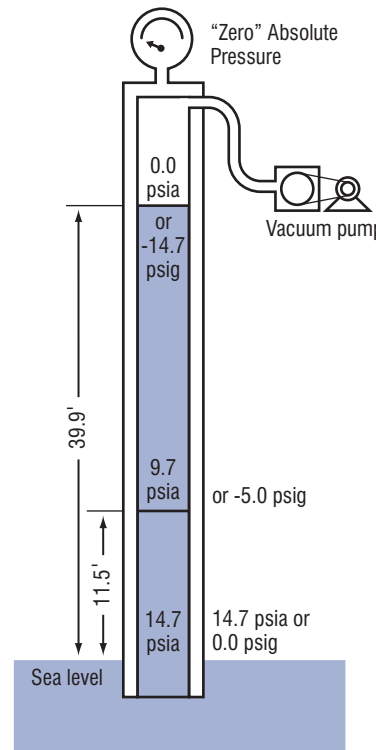


If, as shown in Figure 4, the tube is slightly capped and a vacuum pump is used to evacuate all the air from the sealed tube, a vacuum with a pressure of 0 psia is created within the tube. Because the pressure at any point in a static fluid is dependent upon the height of that point above a reference line, such as sea level, it follows that the pressure within the tube at sea level must still be 14.7 psia. This is equivalent to the pressure at the base of a column of water 33.9 feet high and with the column open at the base, water would rise to fill the column to a depth of 33.9 feet. In other words, the weight of the atmosphere at sea

level exactly balances the weight of a column of water 33.9 feet in height. The absolute pressure within the column of water in Figure 4 at a height of 11.5 feet is equal to 9.7 psia. This is a partial vacuum with an equivalent gage pressure of -5.0 psig.

As a practical example, assume the water pressure at a closed faucet on the top of a 100-foot high building to be 20 psig; the pressure on the ground floor would then be 63.3 psig. If the pressure at the ground were to drop suddenly due to a heavy fire demand in the area to 33.3 psig, the pressure at the top would be reduced to -10 psig. If the building water system were airtight, the water would remain at the level of the faucet

FIGURE 4. Effect of evacuating air from a column.



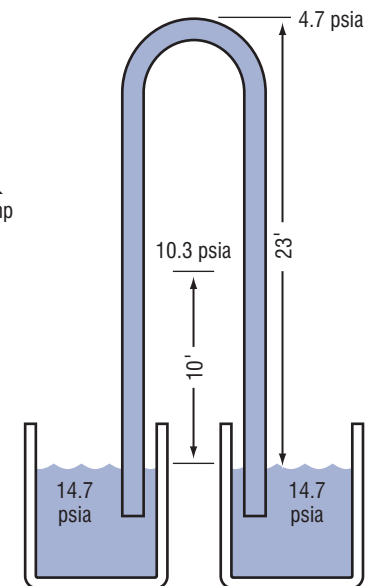
because of the partial vacuum created by the drop in pressure. If the faucet were opened, however, the vacuum would be broken and the water level would drop to a height of 77 feet above the ground. Thus, the atmosphere was supporting a column of water 23 feet high.

Figure 5 is a diagram of an inverted U-tube that has been filled with water and placed in two open containers at sea level.

If the open containers are placed so that the liquid levels in each container are at the same height, a static state will exist; and the pressure at any specified level in either leg of the U-tube will be the same.

The equilibrium condition is altered by raising one of the containers so that the liquid level in one container is 5 feet

FIGURE 5. Pressure relationships in a continuous fluid system at the same elevation.



above the level of the other. (See Fig. 6.) Since both containers are open to the atmosphere, the pressure on the liquid surfaces in each container will remain at 14.7 psia.

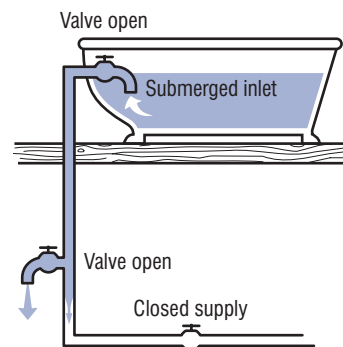
If it is assumed that a static state exists, momentarily, within the system shown in Figure 6, the pressure in the left tube at any height above the free surface in the left container can be calculated. The pressure at the corresponding level in the right tube above the free surface in the right container may also be calculated.

As shown in Figure 6, the pressure at all levels in the left tube would be less than at corresponding levels in the right tube. In this case, a static condition cannot exist because fluid will flow from the higher pressure to the lower pressure; the flow would be from the right tank to the left tank. This arrangement will be recognized as a siphon. The crest of a siphon cannot be higher than 33.9 feet above the upper liquid

level, since atmosphere cannot support a column of water greater in height than 33.9 feet.

Figure 7 illustrates how this siphon principle can be hazardous in a plumbing system. If the supply valve is closed, the pressure in the line supplying the faucet is less than the pressure in the supply line to the bathtub. Flow will occur, therefore, through siphonage, from the bathtub to the open faucet.

FIGURE 7. Backsiphonage in a plumbing system.

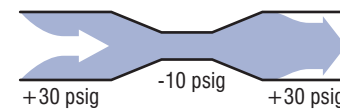


The siphon actions cited have been produced by reduced pressures resulting from a difference in the water levels at two separated points within a continuous fluid system.

Reduced pressure may also be created within a fluid system as a result of fluid motion. One of the basic principles of fluid mechanics is the principle of conservation of energy. Based upon this principle, it may be

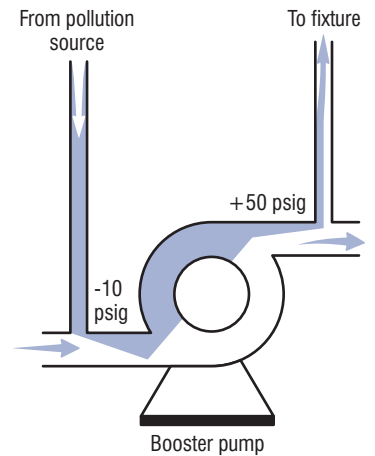
shown that as a fluid accelerates, as shown in Figure 8, the pressure is reduced. As water flows through a constriction such as a converging section of pipe, the velocity of the water increases; as a result, the pressure is reduced. Under such conditions, negative pressures may be developed in a pipe. The simple aspirator is based upon this principle. If this point of reduced pressure is linked to a source of pollution, backsiphonage of the pollutant can occur.

FIGURE 8. Negative pressure created by constricted flow.



One of the common occurrences of dynamically reduced pipe pressures is found on the suction side of a pump. In many cases similar to the one illustrated in Figure 9, the line supplying the booster pump is undersized or does not have sufficient pressure to deliver water at the rate at which the pump normally operates. The rate of flow in the pipe may be increased by a further reduction in pressure at the pump intake. This often results in the creation of negative pressure at the pump intake. This often results in the creation of negative pressure. This negative pressure may become low enough in some cases to cause vaporization of the water in the line. Actually, in the illustration shown,

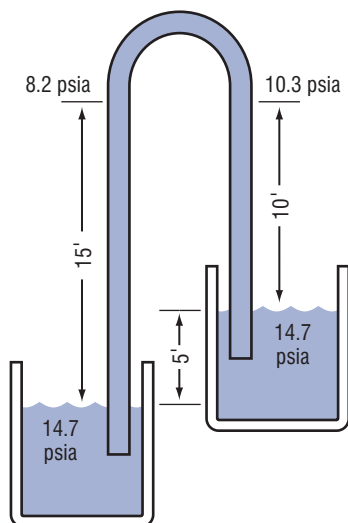
FIGURE 9. Dynamically reduced pipe pressures.



flow from the source of pollution would occur when pressure on the suction side of the pump is less than pressure of the pollution source; but this is *backflow*, which will be discussed below.

The preceding discussion has described some of the means by which negative pressures may be created and which frequently occur to produce backsiphonage. In addition to the negative pressure or reversed force necessary to cause backsiphonage and backflow, there must also be the cross-connection or connecting link between the potable water supply and the source of pollution. Two basic types of connections may be created in piping systems. These are the solid pipe with valved connection and the *submerged inlet*.

FIGURE 6. Pressure relationships in a continuous fluid system at different elevations.



Figures 10 and 11 illustrate solid connections. This type of connection is often installed where it is necessary to supply an auxiliary piping system from the potable source. It is a direct connection of one pipe to another pipe or receptacle.

Solid pipe connections are often made to continuous or intermittent waste lines where it is assumed that the flow will be in one direction only. An example of this would be used cooling water from a water jacket or condenser as shown in Figure 11. This type of connection is usually detectable but creating a concern on the part

of the installer about the possibility of reversed flow is often more difficult. Upon questioning, however, many installers will agree that the solid connection was made because the sewer is occasionally subjected to backpressure.

Submerged inlets are found on many common plumbing fixtures and are sometimes necessary features of the fixtures if they are to function properly. Examples of this type of design are siphon-jet urinals or water closets, flushing rim slop sinks, and dental cuspidors. Oldstyle bathtubs and lavatories had supply inlets below the flood level rims, but modern sanitary design has minimized or eliminated this hazard in new fixtures. Chemical and industrial process vats sometimes have submerged inlets where the water pressure is used as an aid in diffusion, dispersion and agitation of the vat contents. Even though the supply pipe may come from the floor above the vat, backsiphonage can occur as it has been shown that the siphon action can raise a liquid such as water almost 34 feet. Some submerged inlets

difficult to control are those which are not apparent until a significant change in water level occurs or where a supply may be conveniently extended below the liquid surface by means of a hose or auxiliary piping. A submerged inlet may be created in numerous ways, and its detection in some of these subtle forms may be difficult.

The illustrations included in part B of the appendix are intended to describe typical examples of backsiphonage, showing in each case the nature of the link or cross-connection, and the cause of the negative pressure.

Backflow

Backflow¹, as described in this manual, refers to reversed flow due to backpressure other than siphonic action. Any interconnected fluid systems in which the pressure of one exceeds the pressure of the other may have flow from one to the other as a result of the pressure differential. The flow will occur from the zone of higher pressure to the zone of lower pressure. This type of backflow is of concern in buildings where two or more piping systems are maintained. The potable water supply is usually under pressure directly from the city water main. Occasionally, a booster pump is used. The auxiliary system is often pressurized by a centrifugal pump, although backpressure may be caused by gas or steam pressure from a boiler. A

reversal in differential pressure may occur when pressure in the potable system drops, for some reason, to a pressure lower than that in the system to which the potable water is connected.

The most positive method of avoiding this type of backflow is the total or complete separation of the two systems. Other methods used involve the installation of mechanical devices. All methods require routine inspection and maintenance.

Dual piping systems are often installed for extra protection in the event of an emergency or possible mechanical failure of one of the systems. Fire protection systems are an example. Another example is the use of dual water connections to boilers. These installations are sometimes interconnected, thus creating a health hazard.

The illustrations in part C of the appendix depict installations where backflow under pressure can occur, describing the cross-connection and the cause of the reversed flow.

FIGURE 10.
Valved connections between potable water and nonpotable fluid.

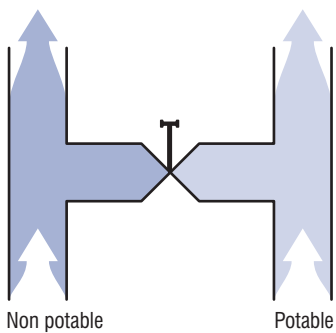
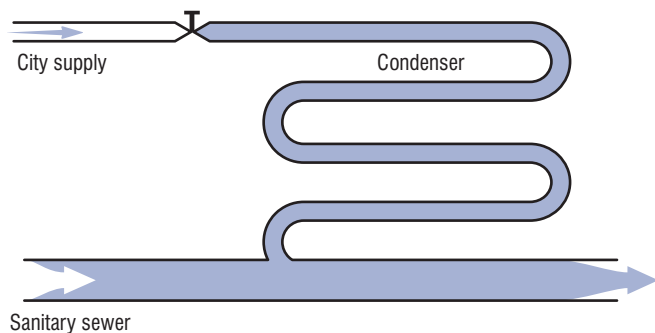


FIGURE 11
Valved connection between potable water and sanitary sewer.



¹See formal definition in the glossary of the appendix

Methods and Devices for the Prevention of Backflow and Back-Siphonage

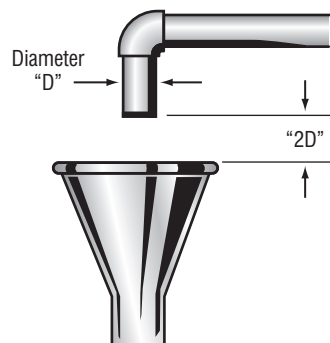
A wide choice of devices exists that can be used to prevent backsiphonage and backpressure from adding contaminated fluids or gases into a potable water supply system. Generally, the selection of the proper device to use is based upon the degree of hazard posed by the cross-connection. Additional considerations are based upon piping size, location, and the potential need to periodically test the devices to insure proper operation.

There are six basic types of devices that can be used to correct cross-connections: air gaps, barometric loops, vacuum breakers—both atmospheric and pressure type, double check with intermediate atmospheric vent, double check valve assemblies, and reduced pressure principle devices. In general, all manufacturers of these devices, with the exception of the barometric loop, produce them to one or more of three basic standards, thus insuring the public that dependable devices are being utilized and marketed. The major standards in the industry are: American Society of Sanitary Engineers ASSE), American Water Works Association (AWWA), and the University of California Foundation for Cross-Connection Control and Hydraulic Research.

Air Gap

Air gaps are non-mechanical backflow preventers that are very effective devices to be used where either backsiphonage or backpressure conditions may exist. Their use is as old as piping and plumbing itself, but only relatively recently have standards been issued that standardize their design. In general, the air gap must be twice the supply pipe diameter but never less than one inch. See Figure 12.

FIGURE 12. Air gap.



An air gap, although an extremely effective backflow preventer when used to prevent backsiphonage and backpressure conditions, does interrupt the piping flow with corresponding loss of pressure for subsequent use. Consequently, air gaps are primarily used at end of the line service where reservoirs or storage tanks are desired. When contemplating the use of an air gap, some other considerations are:

(1) In a continuous piping system, each air gap requires the added expense of reservoirs and secondary pumping systems.

(2) The air gap may be easily defeated in the event that the “2D” requirement was purposely or inadvertently compromised. Excessive splash may be encountered in the event that higher than anticipated pressures or flows occur. The splash may be a cosmetic or true potential hazard—the simple solution being to reduce the “2D” dimension by thrusting the supply pipe into the receiving funnel. By so doing, the air gap is defeated.

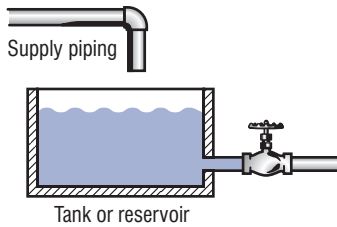
(3) At an air gap, we expose the water to the surrounding air with its inherent bacteria, dust particles, and other airborne pollutants or contaminants. In addition, the aspiration effect of the flowing water can drag down surrounding pollutants into the reservoir or holding tank.

(4) Free chlorine can come out of treated water as a result of the air gap and the resulting splash and churning effect as the water enters the holding tanks. This reduces the ability of the water to withstand bacteria contamination during long term storage.

(5) For the above reasons, air gaps must be inspected as frequently as mechanical backflow preventers. They are not exempt from an in-depth cross-connection control program requiring periodic inspection of all backflow devices.

Air gaps may be fabricated from commercially available plumbing components or purchased as separate units and integrated into plumbing and piping systems. An example of the use of an air gap is shown in Figure 13.

FIGURE 13.
Air gap in a piping system.



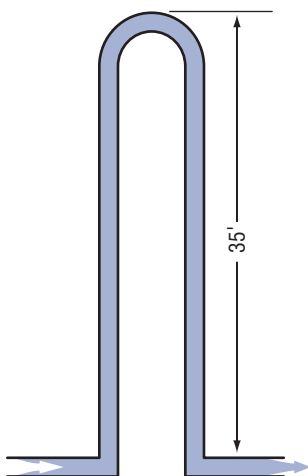
Barometric Loop

The barometric loop consists of a continuous section of supply piping that abruptly rises to a height of approximately 35 feet and then returns back down to the originating level. It is a loop in the piping system that effectively protects against backsiphonage. It may not be used to protect against backpressure.

Its operation, in the protection against backsiphonage, is based upon the principle that a water column, at sea level pressure, will not rise above 33.9 feet (Ref. Chapter 3, Fig. 4 Page 13).

In general, barometric loops are locally fabricated, and are 35 feet high.

FIGURE 14.
Barometric loop.



Atmospheric Vacuum Breaker

These devices are among the simplest and least expensive mechanical types of backflow preventers and, when installed properly, can provide excellent protection against backsiphonage. They must not be utilized to protect against backpressure conditions.

Construction consists usually of a polyethylene float which is free to travel on a shaft and seal in the uppermost position against atmosphere with an elastomeric disc. Water flow lifts the float, which then causes the disc to seal. Water pressure keeps the float in the upward sealed position. Termination of the water supply will cause the disc to drop down venting the unit to atmosphere and thereby opening downstream piping to atmospheric pressure, thus preventing backsiphonage. Figure 15 shows a typical atmospheric breaker.

In general, these devices are available in 1/2-inch through 3-inch size and must be installed vertically, must not have shutoffs downstream, and must be installed at least 6-inches higher than the final outlet. They cannot be tested once they are installed in the plumbing system, but are, for the most part, dependable, trouble-free devices for backsiphonage protection.

FIGURE 15.
Atmospheric vacuum breaker.

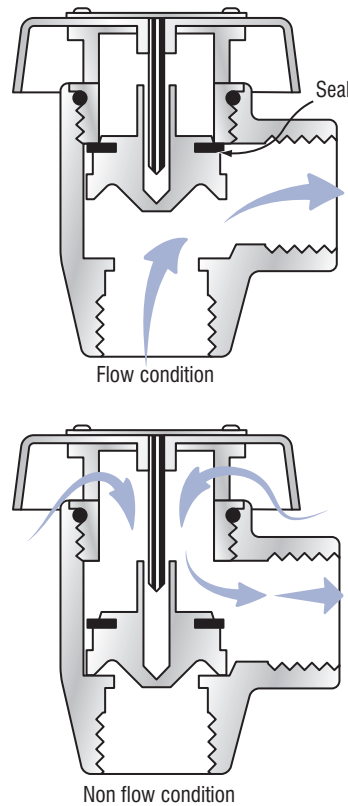


FIGURE 16.
Atmospheric vacuum breaker typical installation.

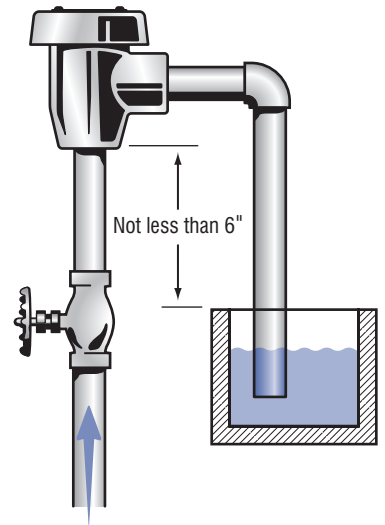


FIGURE 17.
Atmospheric vacuum breaker in plumbing supply system.

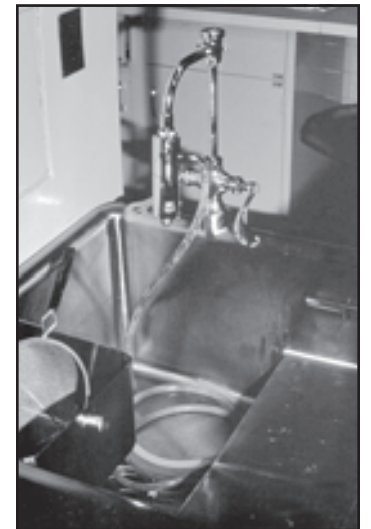


Figure 16 shows the generally accepted installation requirements—note that no shutoff valve is downstream of the device that would otherwise keep the atmospheric vacuum breaker under constant pressure.

Figure 17 shows a typical installation of an atmospheric vacuum breaker in a plumbing supply system.

Hose Bibb Vacuum Breakers

These small devices are a specialized application of the atmospheric vacuum breaker. They are generally attached to sill cocks and in turn are connected to hose supplied outlets such as garden hoses, sloop sink hoses, spray outlets, etc. They consist of a spring loaded check valve that seals against an atmospheric outlet when water supply pressure is turned on. Typical construction is shown in Figure 18.

When the water supply is turned off, the device vents to atmosphere, thus protecting against backsiphonage conditions. They should not be used as backpressure devices. Manual drain options are available, together with tamper-proof versions. A typical installation is shown in Figure 19.

FIGURE 19. Typical installation of hose bibb vacuum breaker.

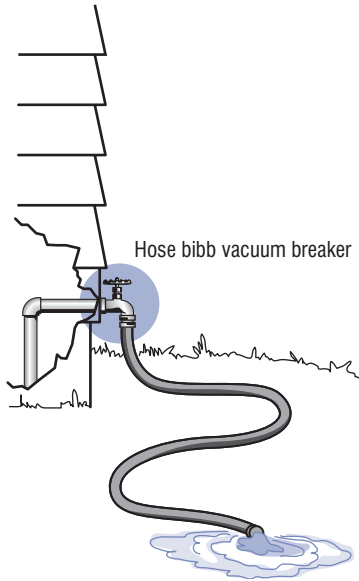
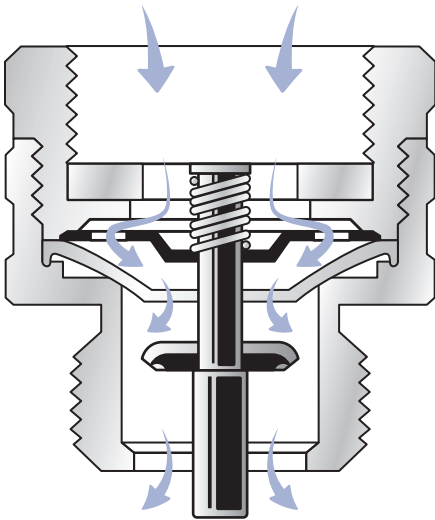


FIGURE 18. Hose bibb vacuum breaker.



Pressure Vacuum Breakers

This device is an outgrowth of the atmospheric vacuum breaker and evolved in response to a need to have an atmospheric vacuum breaker that could be utilized under constant pressure and that could be tested in line. A spring on top of the disc and float assembly, two added gate valves, test cocks, and an additional first check, provided the answer to achieve this device. See Figure 20.

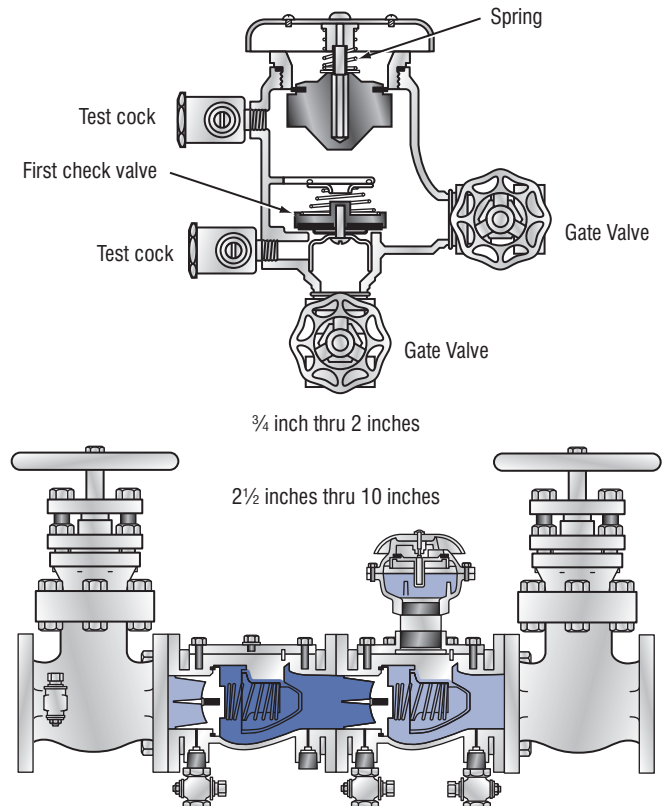
These units are available in the general configurations as shown in Figure 20 in sizes 1/2-inch through 10-inch and have broad usage in the agriculture and irrigation market. Typical agricultural and

industrial applications are shown in Figure 21.

Again, these devices may be used under constant pressure but do not protect against backpressure conditions. As a result, installation must be at least 6- to 12-inches higher than the existing outlet.

A spill resistant pressure vacuum vacuum breaker (SVB) is available that is a modification to the standard pressure vacuum breaker but specifically designed to minimize water spillage. Installation and hydraulic requirements are similar to the standard pressure vacuum breaker and the devices are recommended for internal use.

FIGURE 20. Pressure vacuum breaker



Double Check with Intermediate Atmospheric Vent

The need to provide a compact device in 1/2-inch and 3/4-inch pipe sizes that protects against moderate hazards, is capable of being used under constant pressure and that protects against backpressure, resulted in this unique backflow preventer. Construction is basically a double check valve having an atmospheric vent located between the two checks (See Figure 22).

Line pressure keeps the vent closed, but zero supply pressure or backsiphonage will open the inner chamber to atmosphere. With this device, extra protection is obtained through the atmospheric vent capability. Figure 23 shows a typical use of the device on a residential boiler supply line.

FIGURE 21. Typical agricultural and industrial application of pressure vacuum breaker.

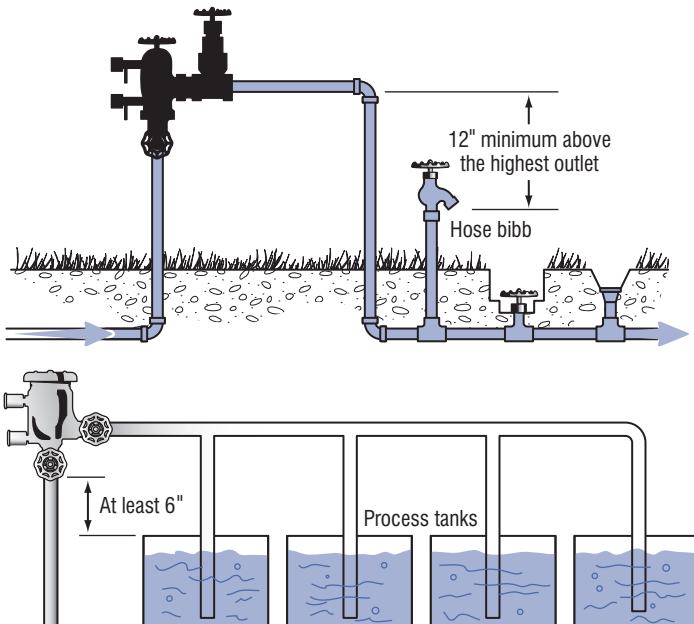


FIGURE 22. Double check valve with atmospheric vent.

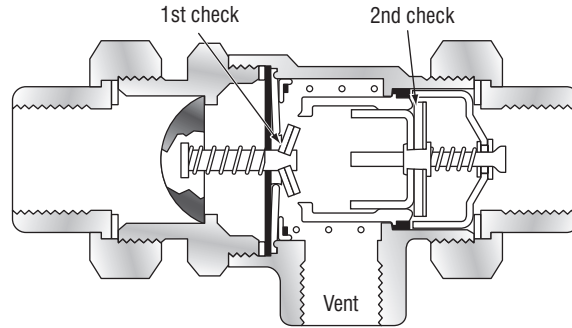
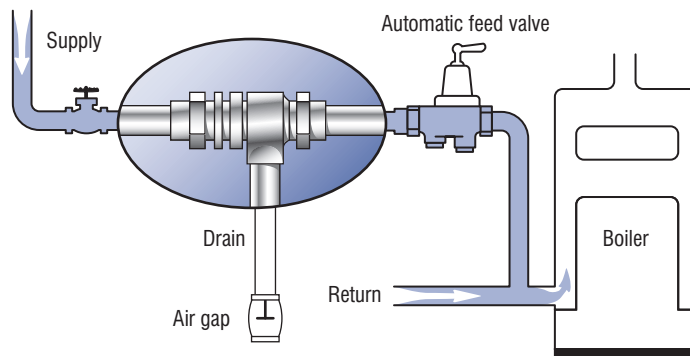


FIGURE 23. Typical residential use of double check with atmospheric vent.



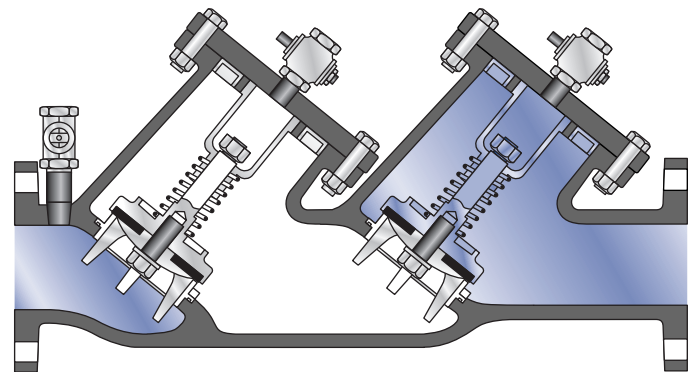
Double Check Valve

A double check valve is essentially two single check valves coupled within one body and furnished with test cocks and two tightly closing gate valves (See Figure 24).

The test capability feature gives this device a big advantage over the use of two independent check valves in that it can be readily tested to determine if either or both check valves are inoperative or fouled by debris. Each check is spring loaded closed and requires approximately a pound of pressure to open.

This spring loading provides the ability to “bite” through small debris and still seal—a protection feature not prevalent in unloaded swing check valves. Figure 24 shows a cross section of double check valve complete with test cocks. Double checks are commonly used to protect against low to medium hazard installations such as food processing steam kettles and apartment projects. They may be used under continuous pressure and protect against both backsiphonage and backpressure conditions.

FIGURE 24. Double check valve.

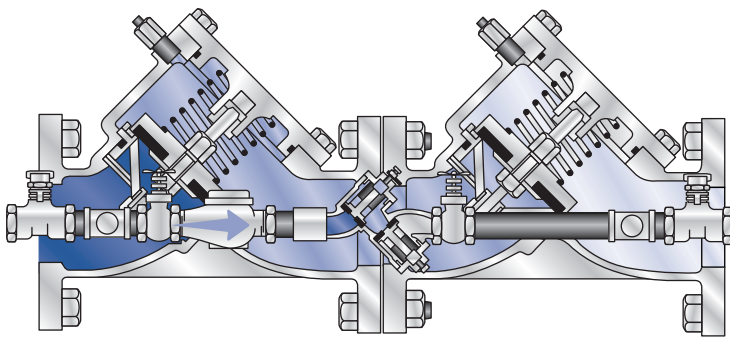


Double Check Detector Check

This device is an outgrowth of the double check valve and is primarily utilized in fire line installations. Its purpose is to protect the potable supply line from possible contamination or pollution from fire line chemical additives, booster pump fire line backpressure, stagnant “black water” that sits in fire lines over extended periods of time, the addition of “raw” water through outside fire pumper connections (Siamese outlets), and the detection of any water movement in the fire line water due to fire line leakage or deliberate water theft. It consists of two, spring loaded check valves, a bypass assembly with water meter and double check valve, and two tightly closing gate valves. See Figure 25. The addition of test cocks makes the device testable

to insure proper operation of both the primary checks and the bypass check valve. In the event of very low fire line water usage, (theft of water) the low pressure drop inherent in the bypass system permits the low flow of water to be metered through the bypass system. In a high flow demand, associated with deluge fire capability, the main check valves open, permitting high volume, low restricted flow, through the two large spring loaded check valves.

FIGURE 25.
Double check detector check.



Residential Dual Check

The need to furnish reliable and inexpensive backsiphonage and backpressure protection for individual residences resulted in the debut of the residential dual check. Protection of the main potable supply from household hazards such as home photograph chemicals, toxic insect and garden sprays, termite control pesticides used by exterminators, etc., reinforced, a true need for such a device. Figure 26 shows a cutaway of the device.

It is sized for 1/2-, 3/4-, and 1-inch service lines and is installed immediately downstream of the water meter. The use of plastic check modules and elimination of test cocks and gate valves keeps the cost reasonable while providing good, dependable protection. Typical installations are shown in Figures 27 and 28.

FIGURE 26.
Residential dual check.

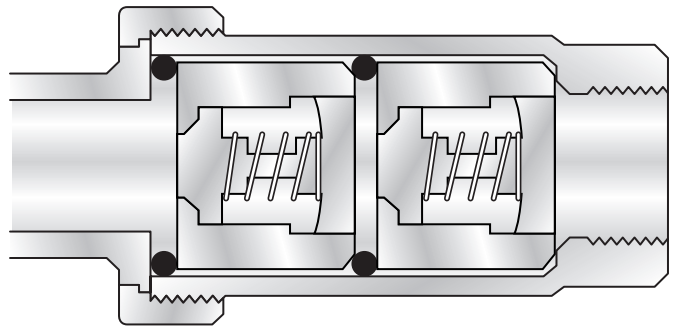


FIGURE 27.
Residential installation.

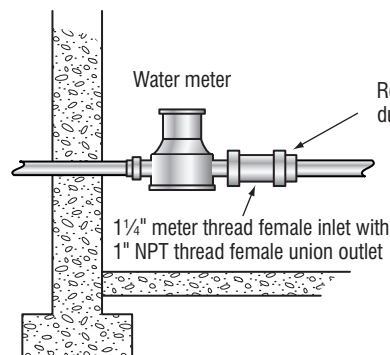
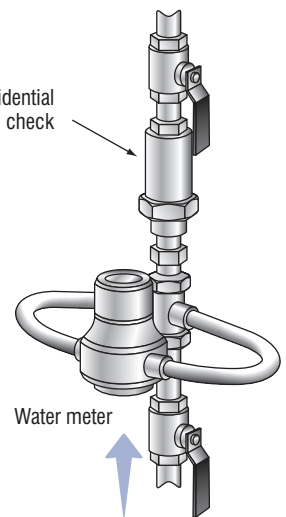


FIGURE 28.
Copper horn.



Reduced Pressure Principle Backflow Preventer

Maximum protection is achieved against backsiphonage and backpressure conditions utilizing reduced pressure principle backflow preventers. These devices are essentially modified double check valves with an atmospheric vent capability placed between the two checks and designed such that this “zone” between the two checks is always kept at least two pounds less than the supply pressure. With this design criteria, the reduced pressure principle backflow preventer can provide protection against backsiphonage and backpressure when both the first and second checks become fouled. They can be used under constant pressure and at high hazard installations. They are furnished with test cocks and gate valves to enable testing and are available in sizes $\frac{3}{4}$ -inch through 10 inch.

Figure 29A shows typical devices representative of $\frac{3}{4}$ -inch through 2-inch size and Figure 29B shows typical devices representative of $2\frac{1}{2}$ -inch through 10-inch sizes.

FIGURE 29A.
Reduced pressure zone backflow preventer ($\frac{3}{4}$ -inch thru 2-inches).

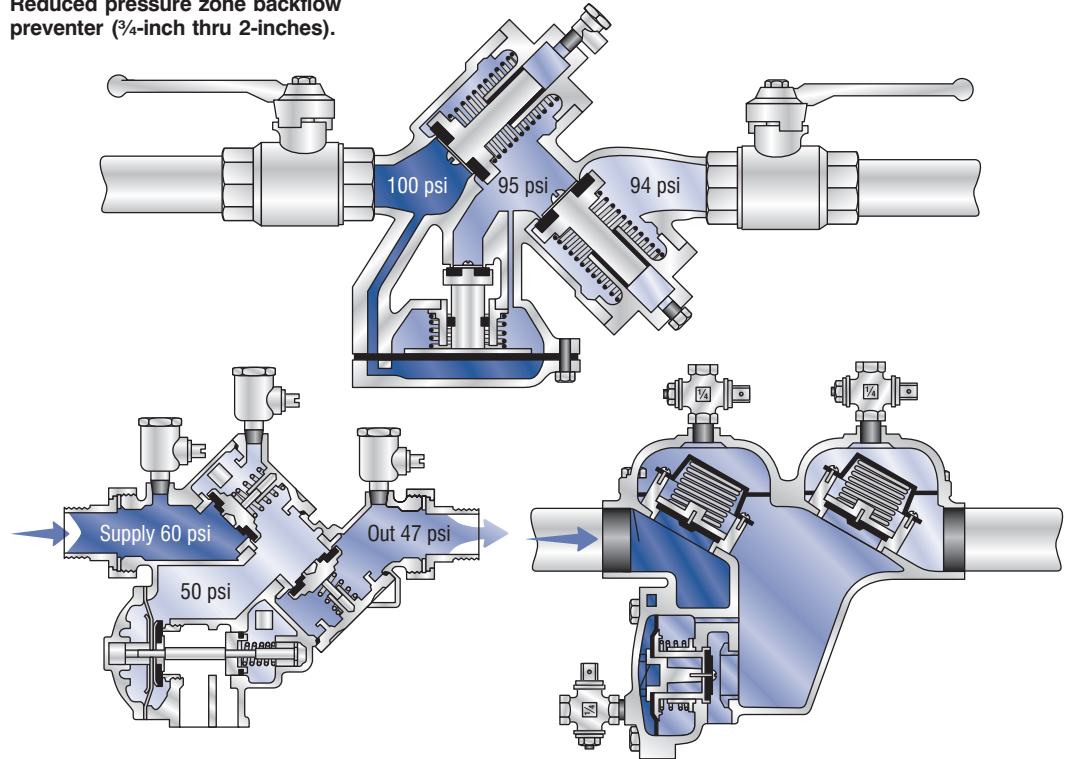
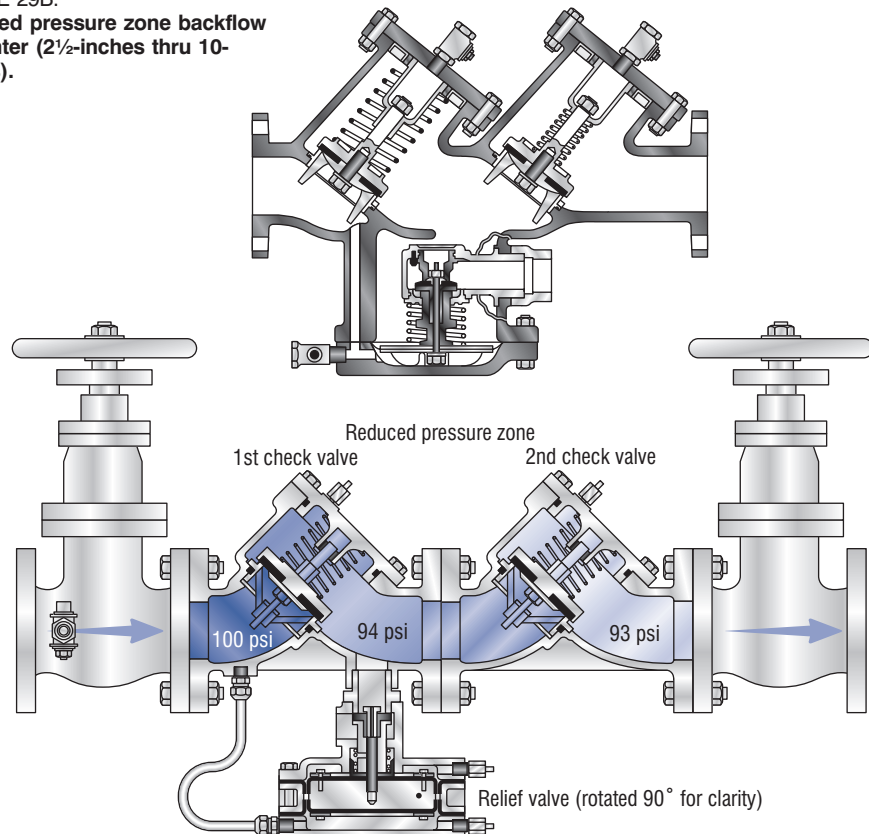


FIGURE 29B.
Reduced pressure zone backflow preventer ($2\frac{1}{2}$ -inches thru 10-inches).



The principles of operation of a reduced pressure principle backflow preventer are as follows:

Flow from the left enters the central chamber against the pressure exerted by the loaded check valve 1. The supply pressure is reduced thereupon by a predetermined amount. The pressure in the central chamber is maintained lower than the incoming supply pressure through the operation of the relief valve 3, which discharges to the atmosphere whenever the central chamber pressure approaches within a few pounds of the inlet pressure. Check valve 2 is lightly loaded to open with a pressure drop of 1 psi in the direction of flow and is independent of the pressure required to open the relief valve. In the event that

the pressure increases downstream from the device, tending to reverse the direction of flow, check valve 2 closes, preventing backflow. Because all valves may leak as a result of wear or obstruction, the protection provided by the check valves is not considered sufficient. If some obstruction prevents check valve 2 from closing tightly, the leakage back into the central chamber would increase the pressure in this zone, the relief valve would open, and flow would be discharged to the atmosphere.

When the supply pressure drops to the minimum differential required to operate the relief valve, the pressure in the central chamber should be atmospheric. If the inlet pressure should become less than atmospheric pressure,

relief valve 3 should remain fully open to the atmosphere to discharge any water which may be caused to backflow as a result of backpressure and leakage of check valve 2.

Malfunctioning of one or both of the check valves or relief valve should always be indicated by a discharge of water from the relief port. Under no circumstances should plugging of the relief port be permitted because the device depends upon an open port for safe operation. The pressure loss through the device may be expected to average between 10 and 20 psi within the normal range of operation, depending upon the size and flow rate of the device.

Reduced pressure principle backflow preventers are commonly installed on high

hazard installations such as plating plants, where they would protect against primarily backsiphonage potential, car washes where they would protect against backpressure conditions, and funeral parlors, hospital autopsy rooms, etc. The reduced pressure principle backflow preventer forms the backbone of cross-connection control programs. Since it is utilized to protect against high hazard installations, and since high hazard installations are the first consideration in protecting public health and safety, these devices are installed in large quantities over a broad range of plumbing and water works installations. Figures 31 and 32 show typical installations of these devices on high hazard installations.

FIGURE 30.
Reduced pressure zone backflow preventer — principle of operation.

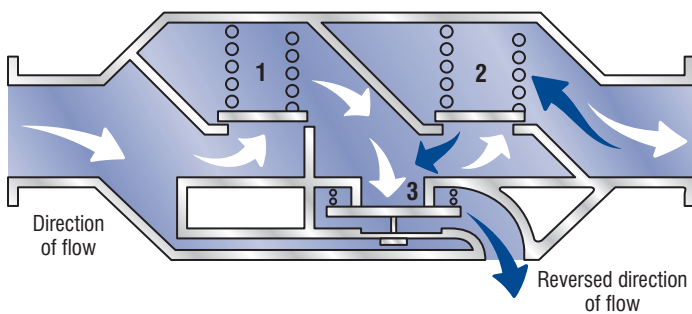


FIGURE 31.
Plating plant installation.

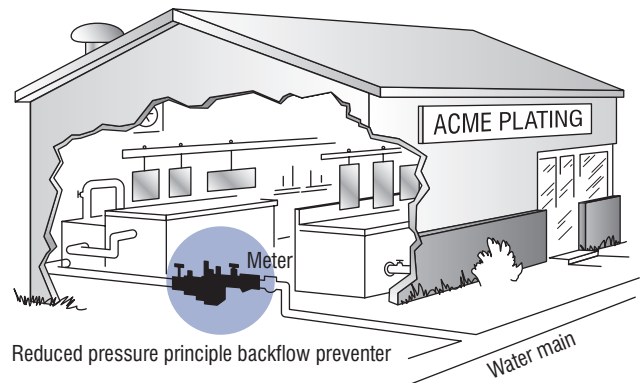


FIGURE 32.
Car wash installation.

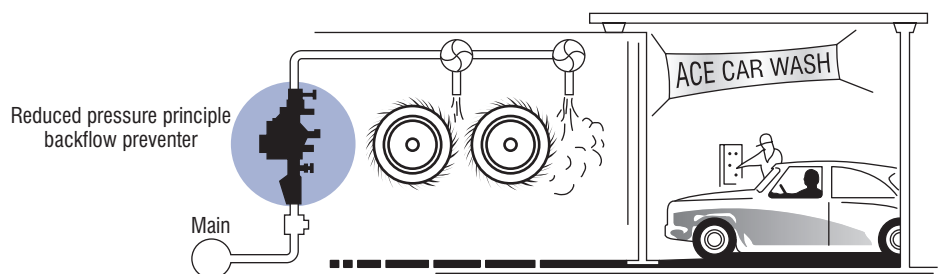
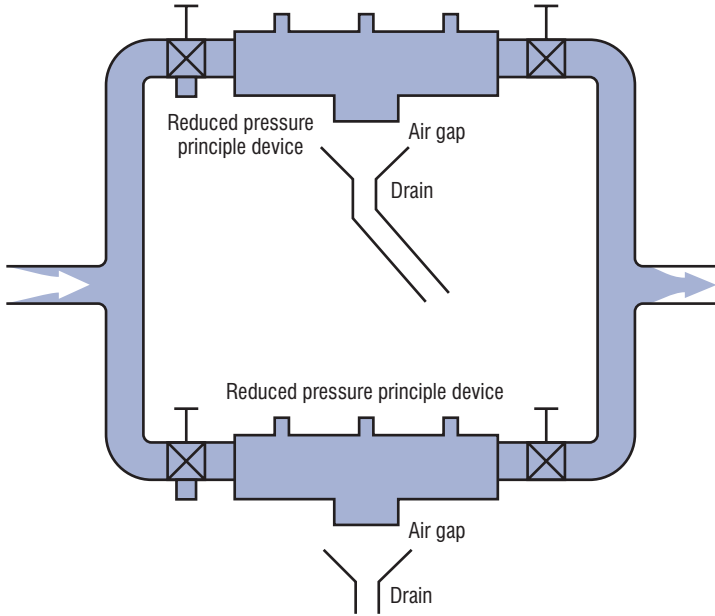


FIGURE 33.
Typical bypass configuration
reduced pressure principle
devices



Note: Devices to be set a min. of 12" and a max. of 30" from the floor and 12" from any wall.

Typical fire line installation double
check valve vertical installation.

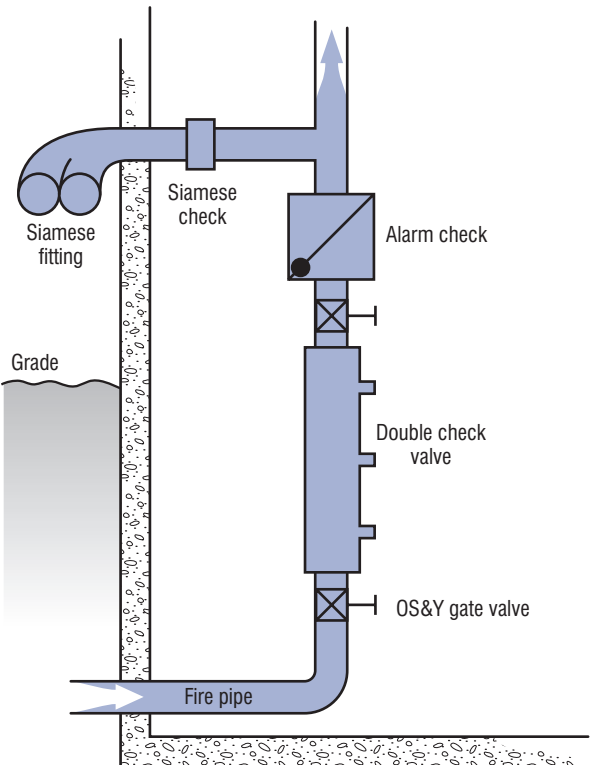


FIGURE 34.
Typical installation reduced
pressure principle device
horizontal illustration.

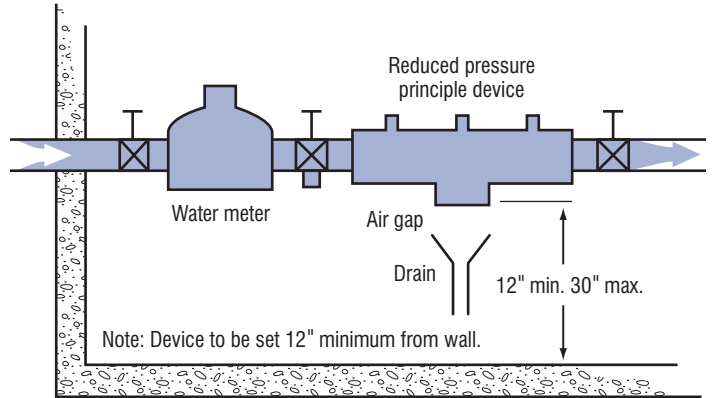
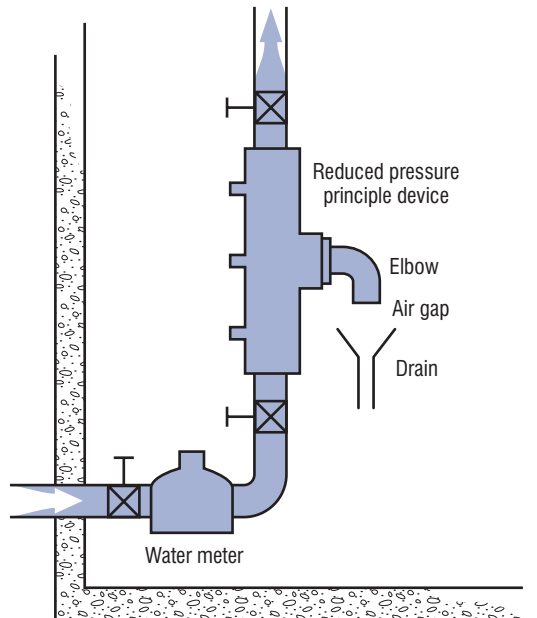


FIGURE 35.
Typical installation reduced
pressure principle device vertical
illustration.



Note: (1) Refer to manufacturers installation data for vertical mount.
 (2) Unit to be set at a height to permit ready access for testing and service.
 (3) Vertical installation only to be used if horizontal installation cannot be achieved.

FIGURE 36.
Typical installation double check valve horizontal and vertical installation.

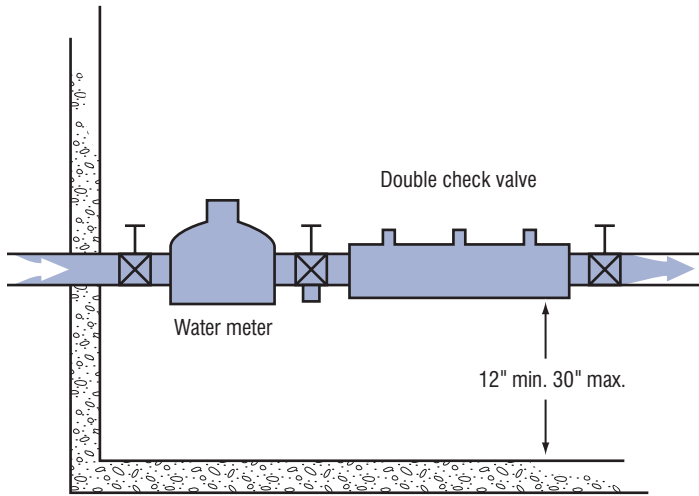
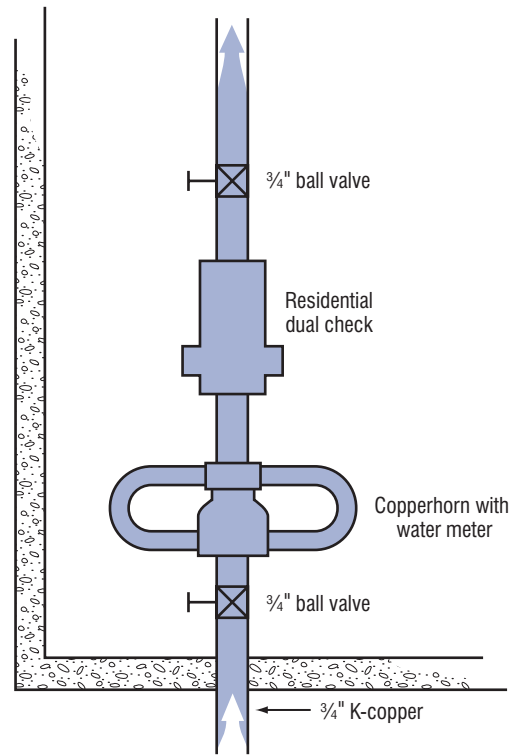
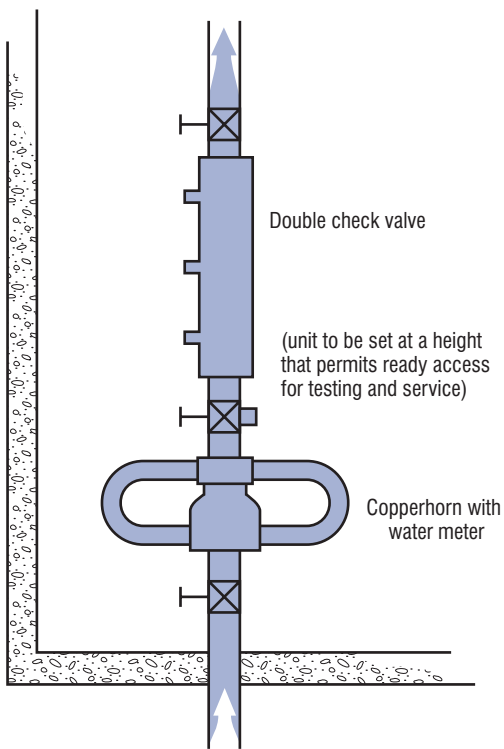
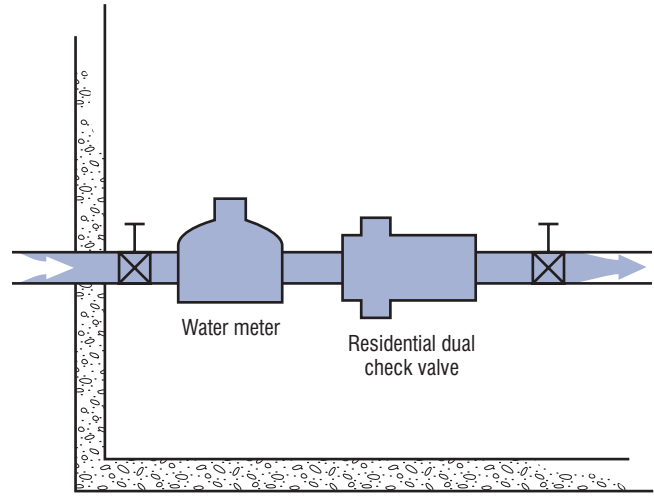


FIGURE 37.
Typical installation residential dual check with straight set and copperhorn.



Note: Vertical installation only to be used if horizontal installation cannot be achieved.